

LETTERS TO THE EDITOR.

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Mont Pelée Eruption and Dust Falls.

FALLS of dust are caused in two ways; either the dust, as for instance Sahara sand, is transported by means of the lower air-currents over wide areas, or matter is ejected from volcanoes, thrown high up into the air and carried by the upper currents, falling eventually in places at great distances from the seat of disturbance. The eruption of Krakatō is a good example of the latter case, while the dust fall that occurred last year in March and was recorded in northern Africa, southern and northern Europe is a good representation of the former kind of dust fall.

The occurrence of such falls of dust is very interesting meteorologically, because they afford us means of increasing our knowledge of the actual movements of the air-currents, both low down and high up in our atmosphere. Falls of dust originating from volcanic eruptions are perhaps of greater interest, because the dust in such cases is thrown to very great heights, and we are able to deduce the directions of the currents at this elevation, there being no other method of doing so available.

To those interested in the movements of these upper currents, the recent disastrous eruption of Mont Pelée in Martinique may afford us some valuable information on this subject. From the accounts of the eruption already published, it is found that it occurred on May 8, and we gather from the information supplied by the British schooner *Ocean Traveller*, and printed in the *Times*, that when the ship was about a mile off St. Pierre, the volcano on Mont Pelée exploded. That the eruption was on a stupendous scale is undoubted from the numerous descriptions already made public, and the report from the British steamer *Esé*, which passed St. Pierre, that "she was covered with ashes although five miles distant from the land, and from on board nothing could be seen owing to the impenetrable darkness," gives some idea of the result of the disturbance. Later reports have indicated a further spreading of the dust, the island of Dominica recording a fall of sand on its southern boundary.

It is interesting for a moment to make a brief survey of the atmospheric circulation in the lower and upper reaches of the atmosphere in the region of the West Indies and to the north and south, and see whether we can trace out the probable path of the fine dust thrown into the air.

An examination of the fine pressure charts published in Bartholomew's "Atlas of Meteorology" tells us that during the month of May the West Indies lie between, but a little to the west of, two high-pressure regions, the more northern one being situated in the Atlantic Ocean and that to the south over the centre of South America, the intervening belt being one of low pressure. We also know that the sun has a declination of about 17° north at this time, and as the island of Martinique is situated in latitude about 15° north, the sun therefore passes daily near the zenith of that place, or, in other words, the sun is exerting its greatest heating power. In consequence of this fact, the low-pressure belt has a maximum in this region, and a low-pressure area means that the air is rising from the earth's surface into the higher regions. The two high-pressure areas already mentioned correspond to downcast shafts of air, i.e. air moving from higher to lower regions. With our present knowledge of atmospheric circulation it seems most probable that the heated air, rising into the upper reaches of the atmosphere from the low-pressure region (which includes the West Indies), bifurcates in a north-easterly direction in the northern hemisphere and in a south-easterly direction in the southern hemisphere. Since these currents of air must again reach the earth's surface, where they fall they will give indications of high pressure, i.e. indications of descent of air. As the two high-pressure areas already mentioned lie in the correct positions and directions in relation to the West Indies, it seems very probable that these are the downcast shafts corresponding to the upcast shaft or low-pressure area.

If the circulation above mentioned be correct, then, as the region of the volcanic eruption of Mont Pelée lies in this low-pressure area, some of the finest particles ejected to the upper reaches of the atmosphere might possibly be carried in these

currents and begin to fall in these high-pressure areas. They may also, if the dust be thrown sufficiently high, reach that elevated current of air travelling from east to west and make a circuit of the earth, as was the case in the eruption of Krakatō.

The most favourable position in the northern hemisphere to observe this fall of dust, should there be such, would be probably in the middle of the Atlantic Ocean, and this could only be recorded by passing ships. Since, however, the descending air moves in a spiral manner and in the direction of the hands of a watch, some of this current reaches Britain as a south-west wind, and it will be interesting to see whether any fall be recorded. There seems little doubt, however, that, just as in the case of Krakatō, a great fall of dust fell to the westward of the volcano, so we shall probably soon hear in this case of such records from Mexico and Central America.

Further, the eruption of Krakatō was responsible for the magnificent coloured sunsets that were observed nearly all over the world, and as these were due to the fine dust particles ejected from the volcano—particles at very great altitudes—so it is quite probable that similar effects will ensue from the eruption of Mont Pelée.

It seems desirable, therefore, that information relating to the present eruption should be collected while facts are still in the memory of those who have observed them, and that a complete account be recorded similar to that published on the Krakatō eruption. It is satisfactory to learn that already expeditions are about to be sent from the United States of America to investigate the scene of the eruption.

WILLIAM J. S. LOCKYER.

Symbol for Partial Differentiation.

IN my college days we used the symbol $\left(\frac{du}{dx}\right)_y$ or $\left(\frac{au}{dx}\right)$ (if there was only one other independent variable y) as the differential coefficient when y was constant. I still keep to this symbol. Thus, if k is a certain kind of thermal capacity, $\left(\frac{dk}{dt}\right)_v$ or $\left(\frac{dk}{dt}\right)_p$ or $\left(\frac{dk}{dt}\right)_\phi$ are in my thermodynamic work perfectly definite. The mathematicians have introduced the convenient symbol for a partial differential coefficient $\frac{\partial u}{\partial x}$ and in much work there is no doubt about the meaning. But even in hydrodynamics there is trouble. In thermodynamics there is so much trouble with this symbol that I venture to ask for help.

The German translator of one of my books uses the same symbol $\frac{\partial k}{\partial t}$ for each of the above quite different things. Baynes in his thermodynamics does the same, and so do all other writers; it seems to me that everybody is doing this without thought. Are they writing for the average examination man who does not need to think, or for the real student? If the letter ∂ is to be retained, would it not be possible to use $\frac{\partial k}{\partial t}$ or $\frac{\partial k}{\partial p}$ or $\frac{\partial k}{\partial \phi}$ in the above three cases? I encourage my own students to use ∂ , and I speak in the interest of such men. For myself it does not much matter, as I mean to continue using the symbolism of my youth.

JOHN PERRY.

May 6.

The Pines of Western Asia.

ON p. 15 of NATURE of May 1, it is stated that Herr Hugo Bretzl, in a thesis for his Doctorate at Strassburg, has shown that "the Greeks realised such facts as the absence of the pine in all the countries which intervene between Macedonia and India." That this statement is erroneous is proved by the following facts relating to the distribution of Macedonian and other species of *Pinus* in the countries alluded to. *P. Pinea*, Anatolia and Syria; *P. sylvestris*, Asia Minor, the Caucasus and Tauria; *P. halepensis*, Anatolia, Transcaucasia, Syria; *P. Brutia*, Asia Minor, the Lebanon, N. Persia; *P. Laricio*, Asia Minor. To these should be added various species of *Picea* and *Abies*, which the Greeks may have included under *Pinus*.

J. D. HOOKER.

THE pine referred to is *Pinus excelsa* Wall., which forms a feature of the Macedonian Mountains and also of the Himalayas,

but has not been found between Macedonia and Afghanistan. (Brandis, "Forest Flora of North-West and Central India," p. 511). Our thanks are due to Sir Joseph Hooker for pointing out that the statement as it stands suggests a wrong inference.

THE WRITER OF THE NOTE.

The Kinetic Theory of Planetary Atmospheres.

THE much-debated question of the applicability of the kinetic theory to decide what gases can and what gases cannot exist in the atmospheres of planets is necessarily once more raised by a somewhat striking paper by M. E. Rogovsky in the *Astro-physical Journal* for November, 1901. In performing certain calculations contained in this paper which are embodied in Table III. (p. 254), the author bases his work on the assumption (p. 252) that "... the equation

$$W = \sqrt{\frac{1}{2} \frac{2\pi g}{10^{22}}}$$

where W is the most probable velocity of the molecules of a gas, gives the minimum most probable velocity in a gas which escapes from the surface of the given celestial body."

This is equivalent to assuming that a gas will escape if the velocity required by a molecule in order to overcome the planet's attraction and fly off to infinity (if it does not collide with other molecules) is not more than 10^{22} times the most probable velocity.

Now if we calculate the probability of a molecule attaining a speed of 10 times the most probable velocity (to use round numbers), we find that the expression for this probability involves a factor of the form e^{-100} , that is about 10^{-43} , and this alone is sufficient to show that it is so rare for a molecule to attain a speed of 10 times the most probable velocity that such events cannot possibly have any appreciable effect on the planet's atmosphere.

Let us examine the matter a little closer, and in the first instance let us calculate the average proportion of molecules in any gas which have at any instant speeds of not less than 10 times the most probable velocity. The numerical result we obtain is

$$1 \text{ in } 2.4 \times 10^{42}.$$

To interpret this result, let us suppose we are dealing with a gas one cubic centimetre of which contains 10^{21} molecules; this figure giving a rough estimate of the number of molecules in a cubic centimetre of air of ordinary temperatures and pressures. Then a volume of this gas equal to 2.4 times a cube the side of which is 100 kilometres will have to be taken in order that there may be an average of one molecule moving with a speed of 10 times the most probable velocity.

So far our calculations do not involve any considerations of time, although this must necessarily enter into the problem of escape of gas from a planet's atmosphere. Let us therefore now suppose the mass of gas under consideration to be bounded by a surface S , and let it further be supposed that every molecule which impinges on S with a speed greater than 10 times the most probable velocity escapes. Let the most probable velocity of the molecules be 1093 metres per second, the number assumed by M. Rogovsky for helium on p. 252 of his paper.

Then in order that the number of molecules removed in this way may be equal to the removal of a layer of the gas 1 millimetre thick all over the surface S , it will be necessary for about 2.8×10^{28} years to elapse.

Next suppose the surface S to be equal in area to the surface of our earth, namely a sphere 4×10^4 kilometres $- 4 \times 10^9$ centimetres in circumference. How many years would it take for a cubic centimetre of gas to escape? The answer comes out to be about 5.371×10^{10} years.

The only conclusion which can be drawn, not only from the present calculations, but also from others of a similar character¹ which have been made, is that a gas cannot escape from the atmosphere of a planet by the motion of its molecules among themselves without the aid of extraneous causes unless the most probable velocity of the molecules is considerably greater than one-tenth of the velocity required to overcome the planet's attraction.

¹ *Phil. Trans. A*, vol. xcxcv, pp. 1-24 (1901); also S. R. Cook, *Astro-physical Journal* January, 1900.

If helium is actually at the present time escaping from our atmosphere, its escape must be due to entirely different causes, and has to be investigated by entirely different methods from those contained in M. Rogovsky's paper. At all events, a most probable molecular velocity of not more than one-tenth, corresponding to a kinetic energy of not more than one-hundredth of that required to carry a molecule of the gas to infinity cannot have much influence in helping a gas to escape from a planet's atmosphere. And so soon as outside influences are invoked, the ratio of velocities which forms the basis of that portion of M. Rogovsky's work here considered ceases to be the determining factor of the problem.

Bangor.

G. H. BRYAN.

On Prof. Arrhenius' Theory of Cometary Tails and Auroræ.

THE letter of Dr. J. Halm in your number of March 6 is based on two misunderstandings into which the writer could not have fallen if he had seen Arrhenius' original papers (*Physikalische Zeitschrift*, November 1900), or my description of them in the *Popular Science Monthly* (January 1902), instead of the friendly but erroneous notice of my paper in the *Observatory*.

(1) Dr. Halm quotes Prof. Schwarzschild to show that Arrhenius' theory "appears to be incompatible with any assumption which regards the cometary matter as being of a gaseous constituency."

Arrhenius never suggested that gaseous molecules could be propelled by the pressure of light. To quote my account of his theory:—"As the comet approaches the sun, the intense heat causes a violent eruption of hydrocarbon vapours on the side towards the sun. The hydrogen boils off, and the vapours condense into small drops of hydrocarbons with higher boiling points, or ultimately solid carbon is thrown out, finely divided as in an ordinary flame. The largest of these particles fall back to the comet, or if they are not condensed till at a great distance from it, they form tails turned towards the sun. The smaller are driven rapidly from the sun by the pressure of its light, with a speed depending on their size, and form the ordinary tails pointing away from it. That particles of different sizes should be formed from the same comet is natural, since the comet is likely to be formed of heterogeneous materials, and there must be great variety in the circumstances of condensation."

Dr. Halm does mention the idea of condensation into drops, and remarks, "Whether such an assumption can be justified appears to me very doubtful." This, of course, is merely his opinion, and receives no authority from the calculations of Prof. Schwarzschild. Indeed, in a recent letter to me, Arrhenius points out that these results fit the theory remarkably well. As Dr. Halm says, Prof. Schwarzschild reckons that "the corpuscles thrown off in the tails of comets should have diameters not smaller than 0.07μ and not exceeding 1.5μ , supposing the specific gravity of the corpuscle to be that of water."

Now Arrhenius, in his original paper (November 1900), taking the specific gravity of the hydrocarbon drops to be 0.8, calculates the size of the particles required by his theory to account for the curvatures observed in the case of four different comets' tails, and finds them to be 0.1μ , 0.59μ , 0.94μ , 1.25μ . These values are distributed almost exactly over the interval within which light could exert a pressure greater than gravitation, according to the "exhaustive mathematical investigation" of Prof. Schwarzschild published a year later.

(2) Dr. Halm says:—"At any rate Prof. Schwarzschild's profound mathematical investigation makes it absolutely clear that the idea of minute electrically-charged corpuscles—about one-thousandth the size of a hydrogen atom (see *Observatory*)—being propelled by the sun's light towards the earth and causing the various phenomena of auroræ, Gegenschein, &c., receives no support from the mathematical point of view."

A reference to Arrhenius' paper and to my article will show that it is carefully explained in both that the charged (negative) particles are known to form excellent nuclei for condensation. It is the small drops so formed, and not the corpuscles, which, according to Arrhenius, are supposed to be driven off as far as the earth, and beyond it, giving rise to the auroræ, &c. As was seen above, Prof. Schwarzschild's results support such a view.

JOHN COX.

McGill University, Montreal, March 19.